FIG. 1

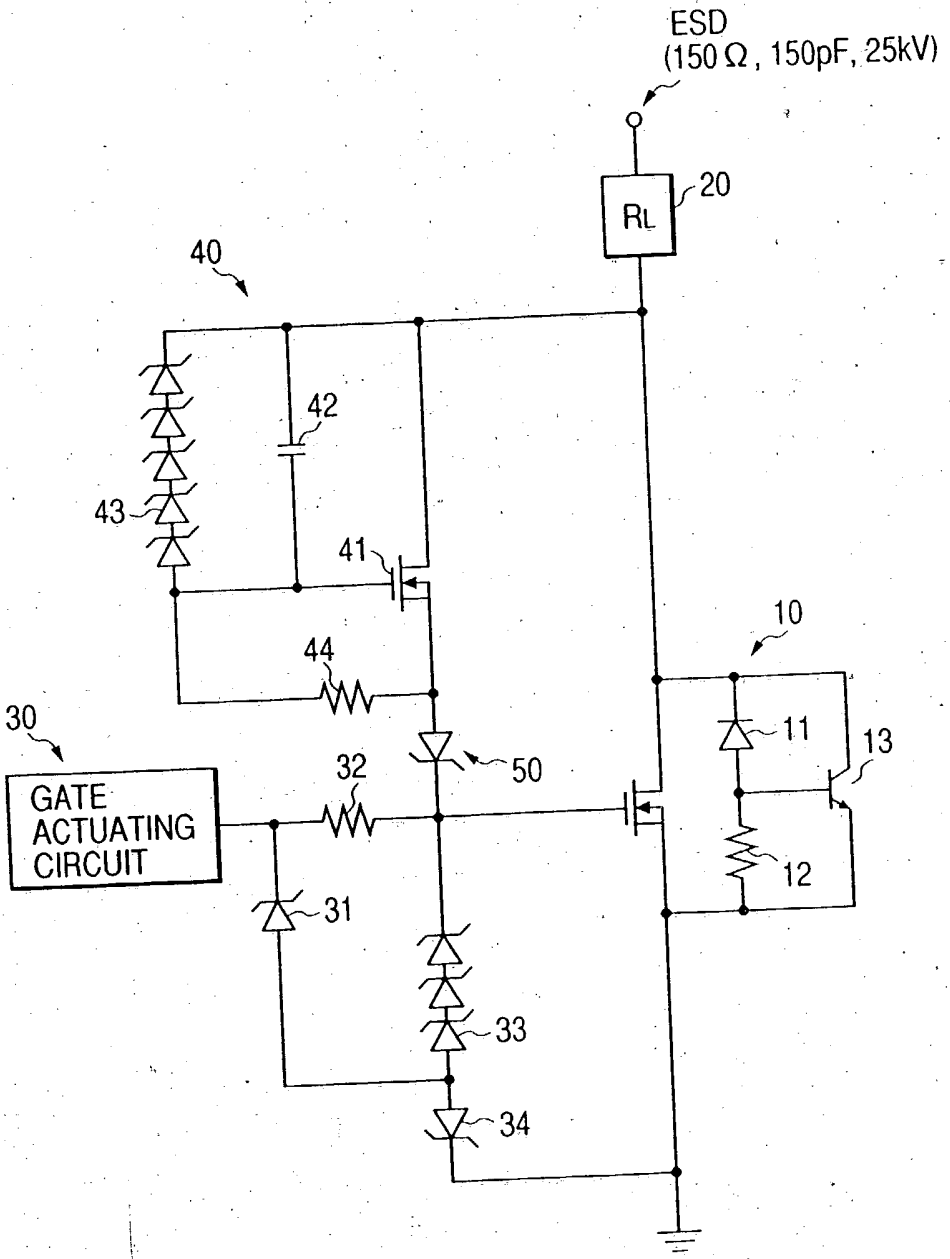

ESD
(150 Ω, 150pF, 25kV)
RL
20
40
42
43
41
44
10
30
11
13
GATE
ACTUATING
CIRCUIT
32
50
12
31
33
34

FIG. 2A

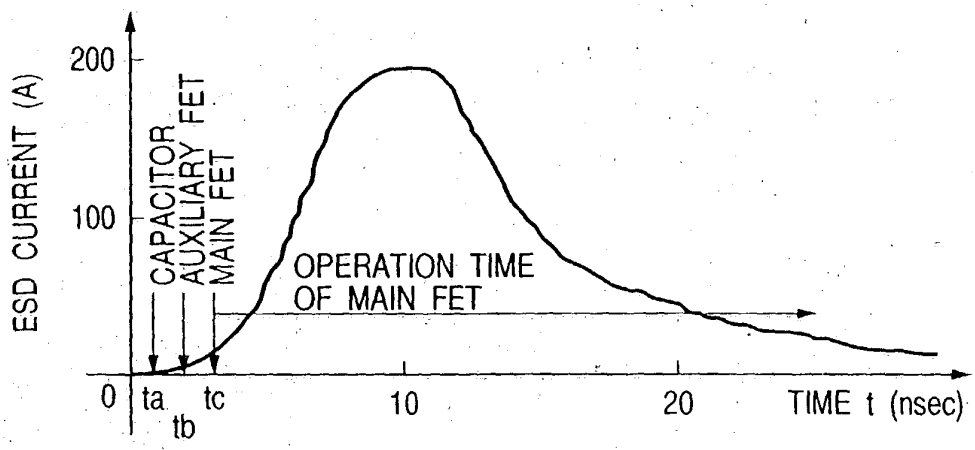

ESD CURRENT (A)
200
100
0
CAPACITOR
AUXILIARY FET
MAIN FET
OPERATION TIME
OF MAIN FET
ta
tb
tc
10
20
TIME t (nsec)

FIG. 2B

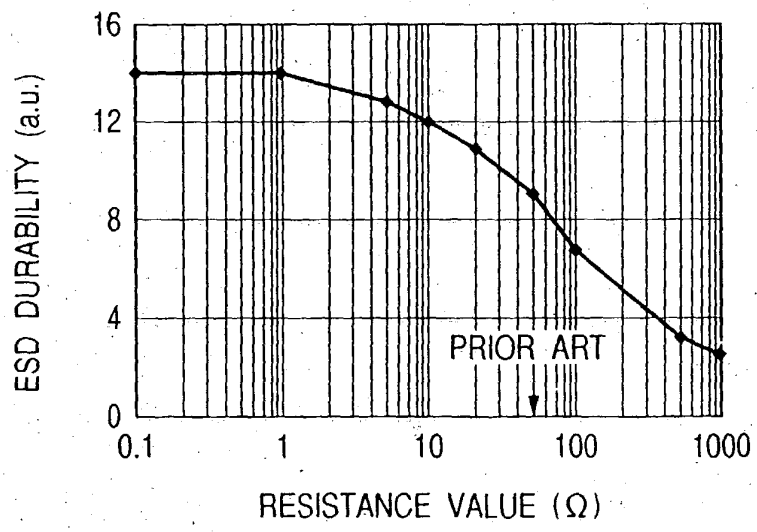

ESD DURABILITY (a.u.)
16
12
8
4
0
PRIOR ART
0.1
1
10
100
1000
RESISTANCE VALUE (Ω)

FIG. 3

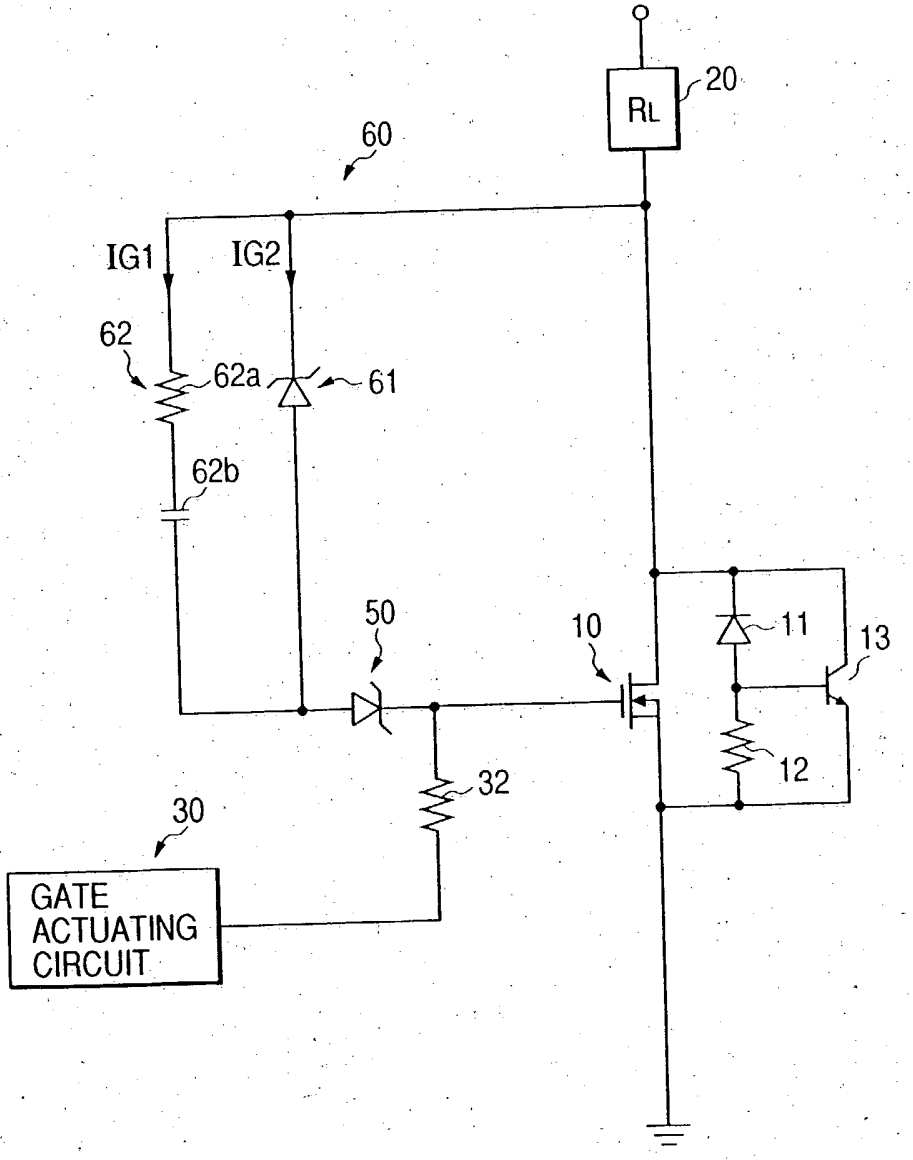

RL
20
60
IG1
IG2
62
62a
61
62b
50
10
11
13
12
32
30
GATE
ACTUATING
CIRCUIT

FIG. 4

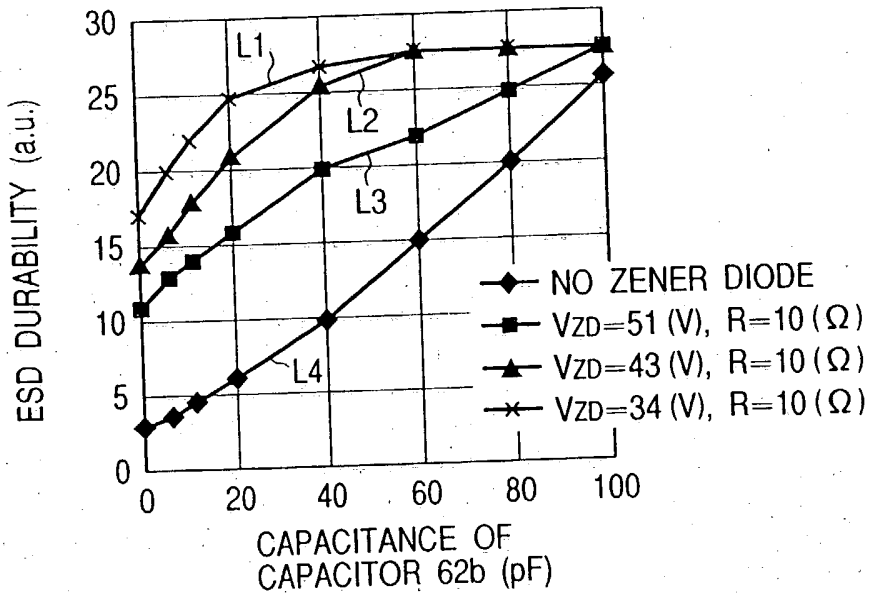

ESD DURABILITY (a.u.)
30
25
20
15
10
5
0
0
20
40
60
80
100
CAPACITANCE OF CAPACITOR 62b (pF)
L1
L2
L3
L4
NO ZENER DIODE
VZD=51 (V), R=10 (Ω)
VZD=43 (V), R=10 (Ω)
VZD=34 (V), R=10 (Ω)

FIG. 5

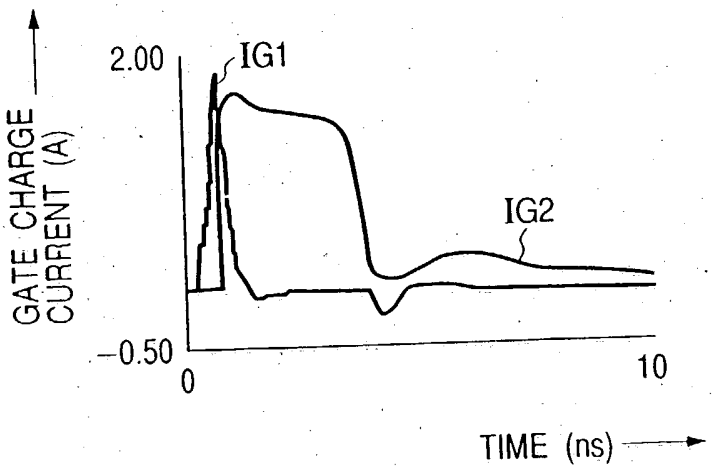

GATE CHARGE CURRENT (A)
2.00
−0.50
0
10
IG1
IG2
TIME (ns)

FIG. 6

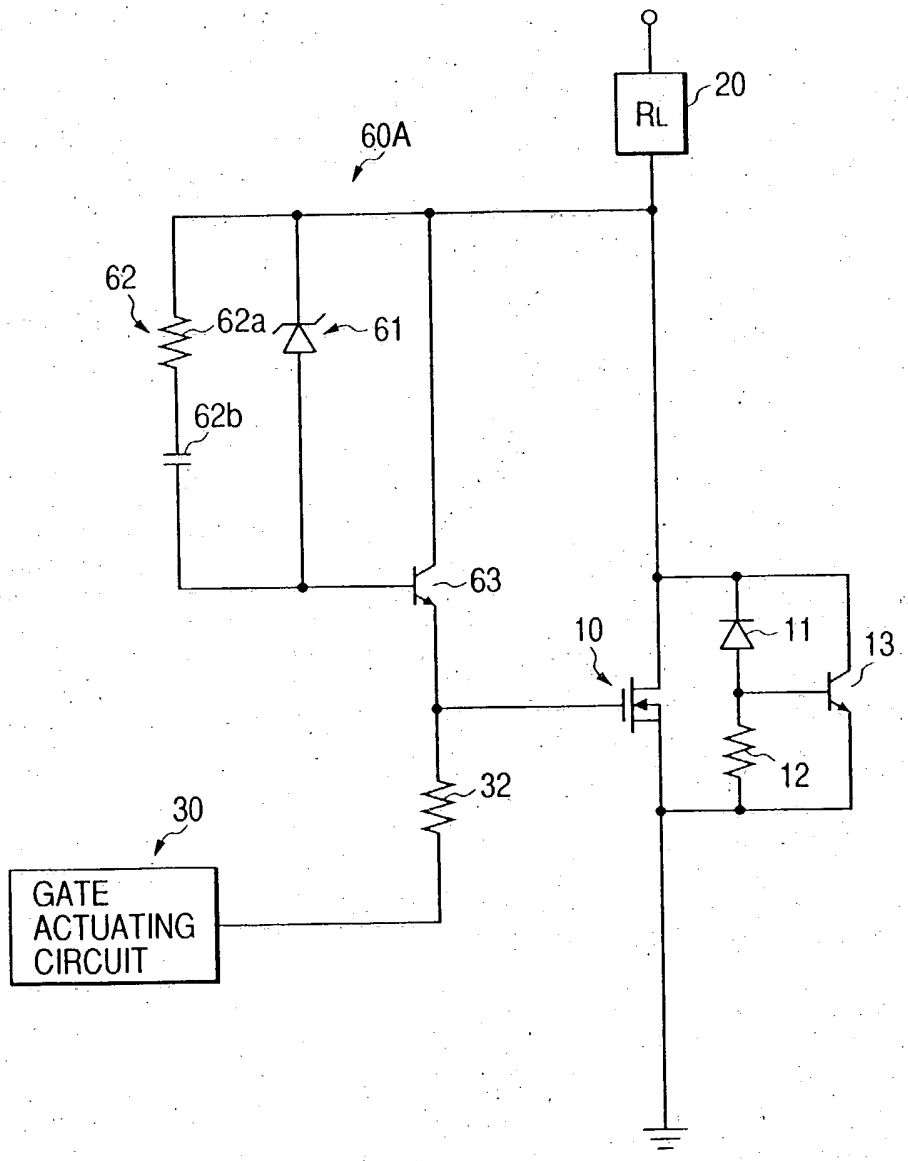

RL
20
60A
62
62a
61
62b
63
10
11
13
12
32
30
GATE
ACTUATING
CIRCUIT

FIG. 7

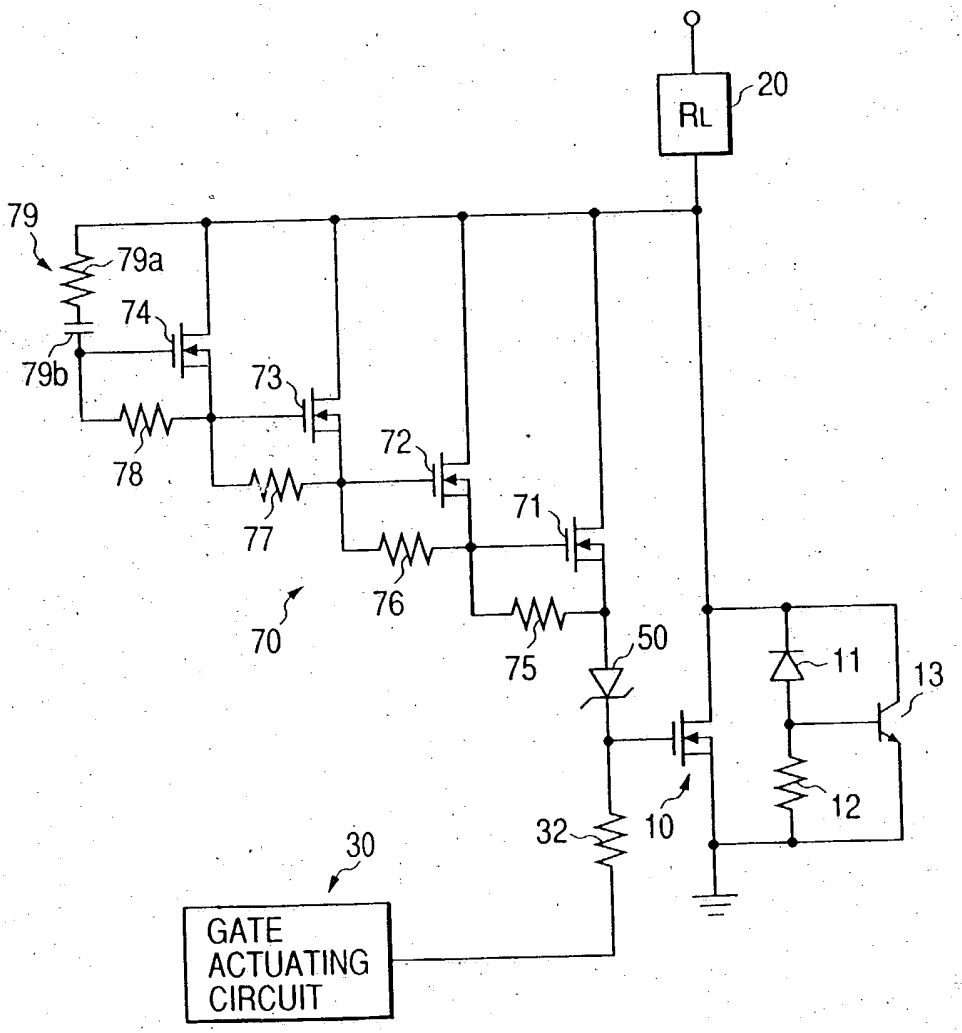

RL
20
79
79a
74
79b
73
78
72
77
71
76
70
75
50
11
13
12
32
10
30
GATE
ACTUATING
CIRCUIT

FIG. 8

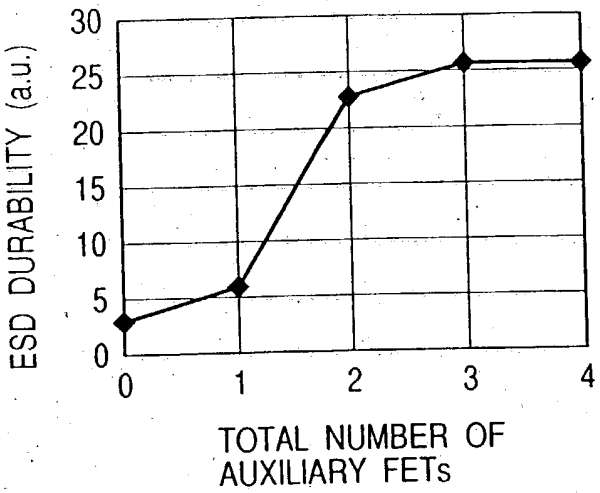


FIG. 10

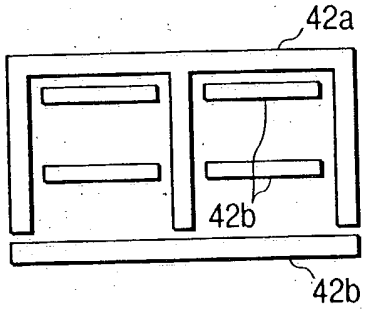


FIG. 11 PRIOR ART

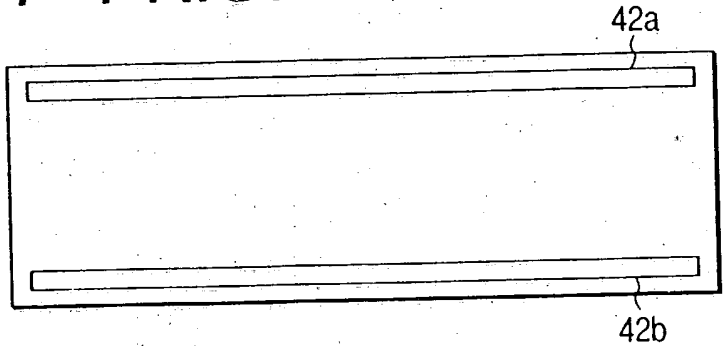


FIG. 9

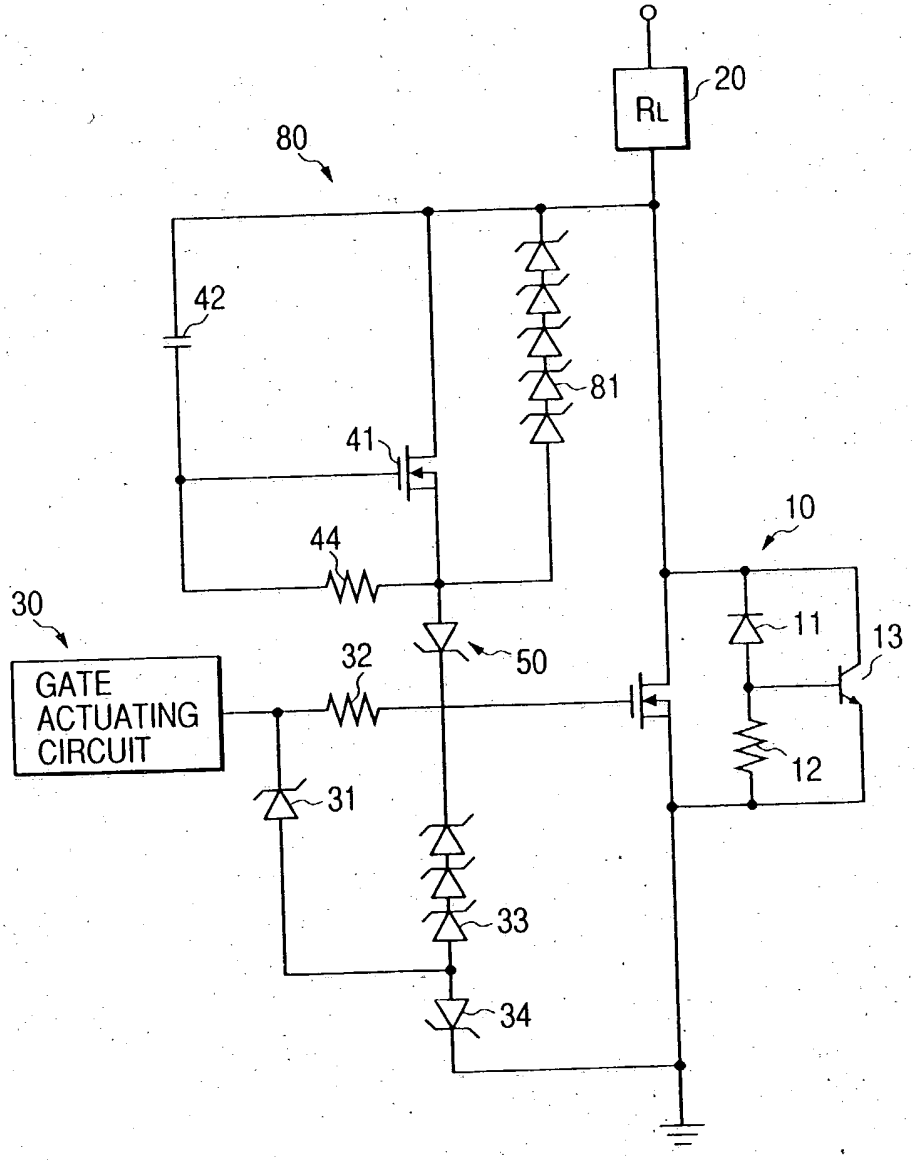

RL
20
80
42
81
41
44
10
30
GATE
ACTUATING
CIRCUIT
32
50
11
13
12
31
33
34

FIG. 12A

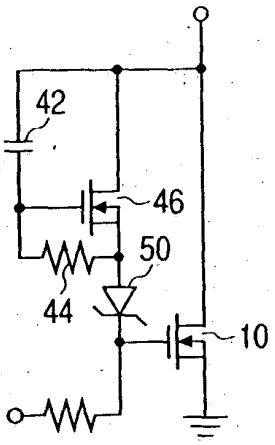


FIG. 12B

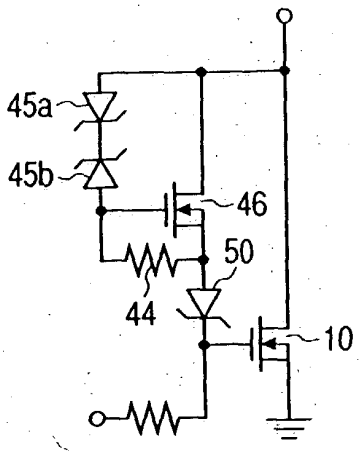


FIG. 14

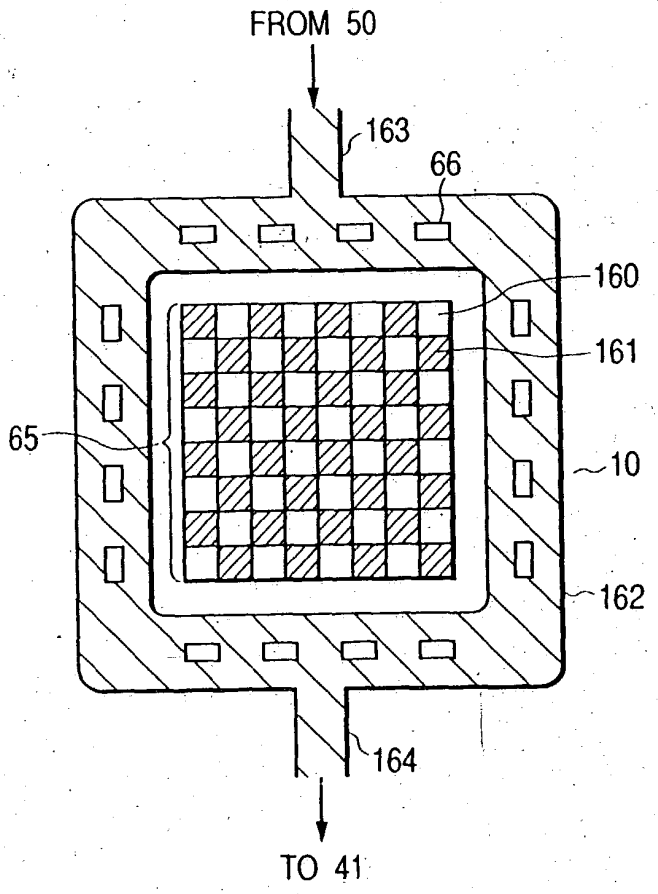


FIG. 13A

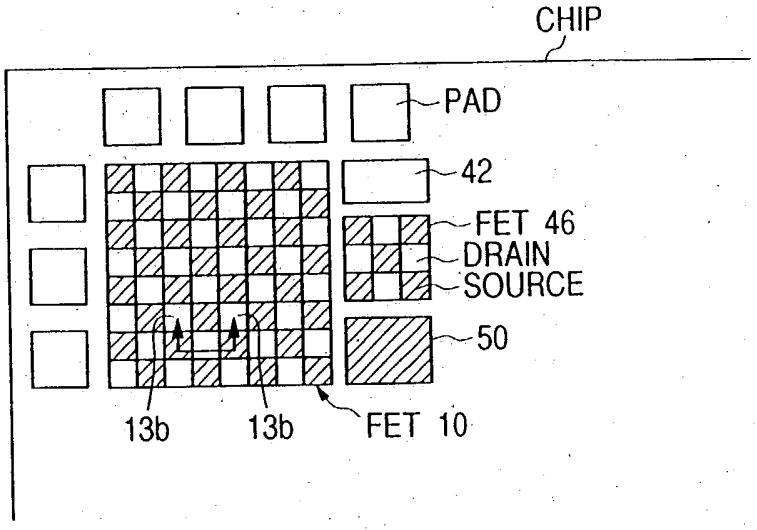


FIG. 13B

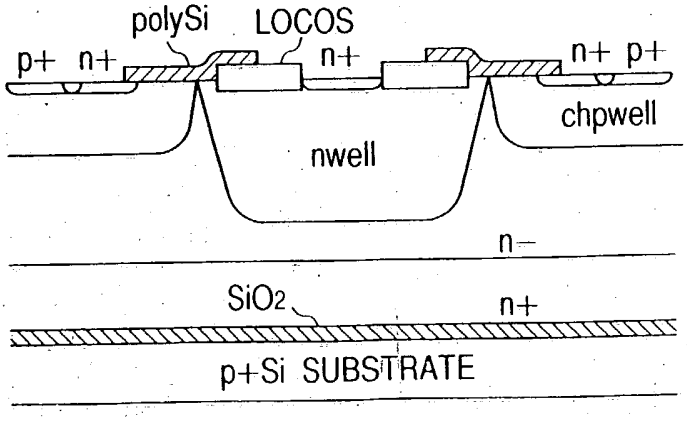


FIG. 15A

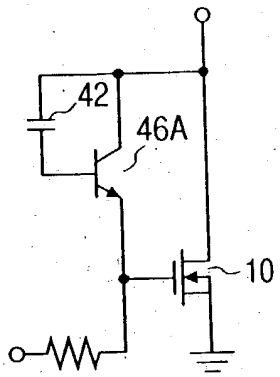


FIG. 15B

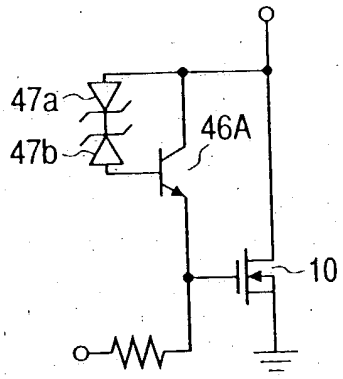


FIG. 16A

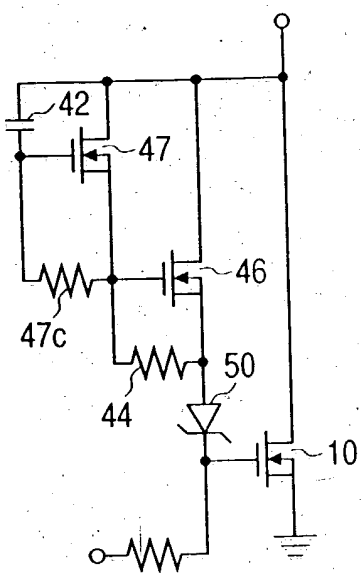


FIG. 16B

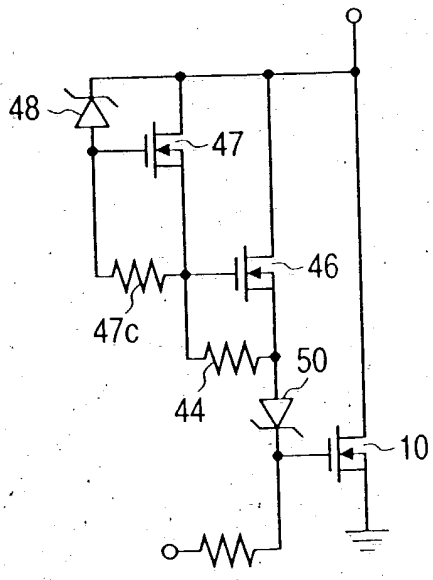


FIG. 17A

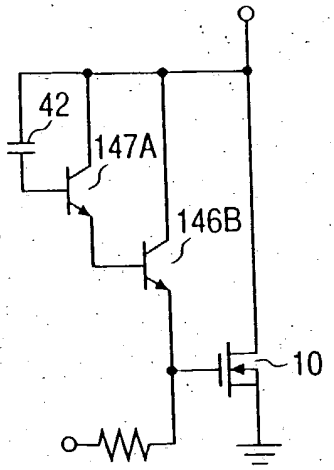


FIG. 17B

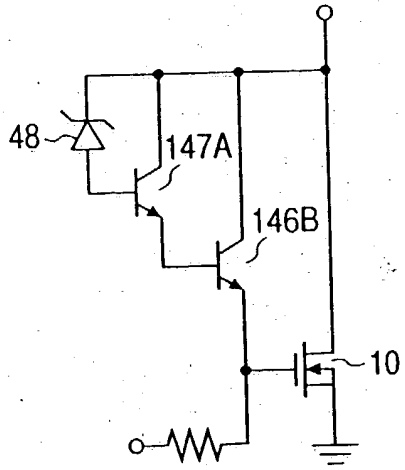


FIG. 18A

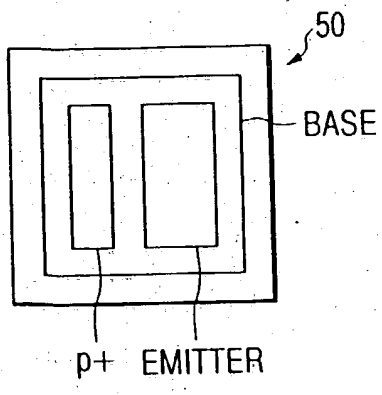


FIG. 18B
PRIOR ART

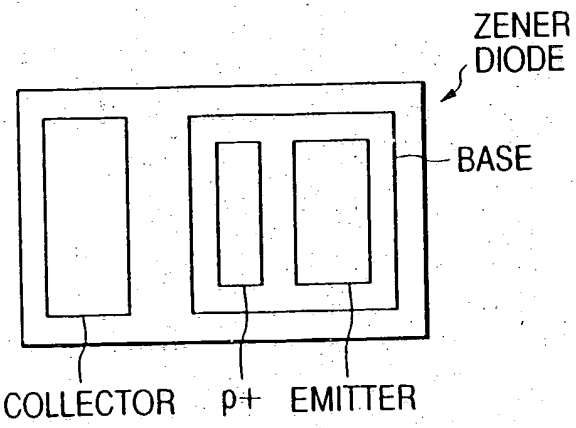


FIG. 19

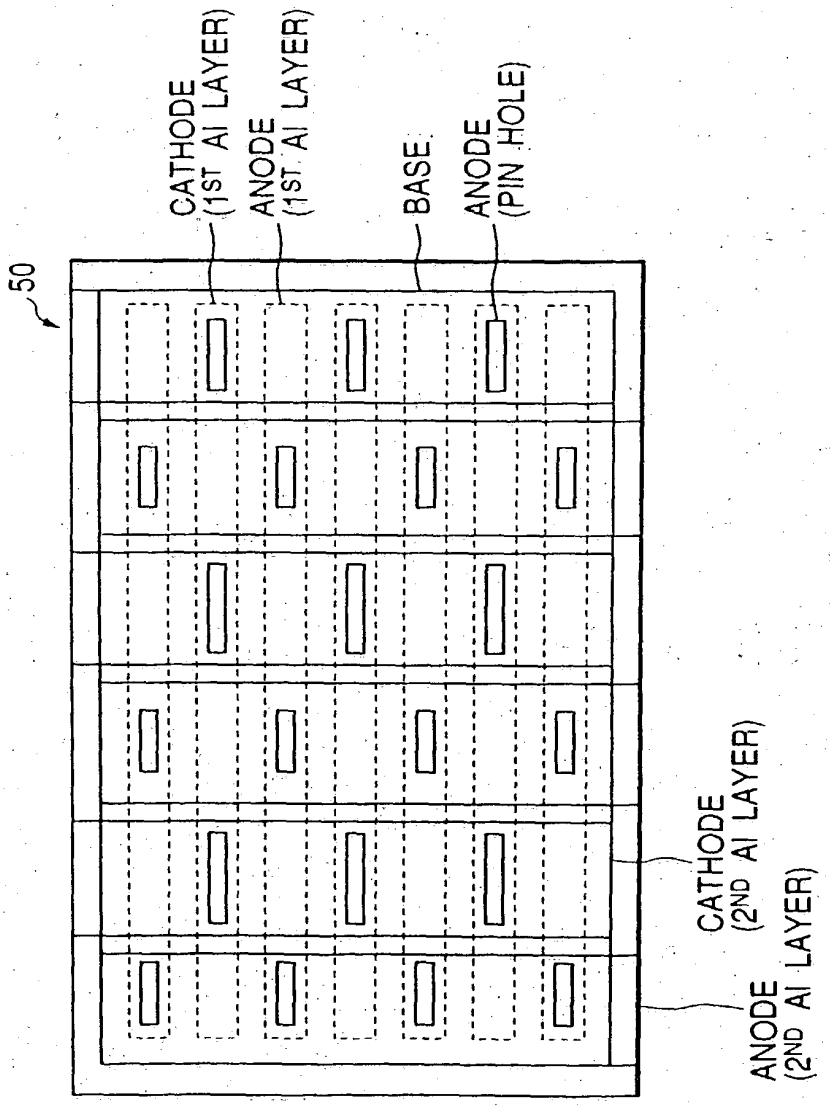

50
CATHODE (1ST Al LAYER)
ANODE (1ST Al LAYER)
BASE
ANODE (PIN HOLE)
CATHODE (2ND Al LAYER)
ANODE (2ND Al LAYER)

FIG. 20A

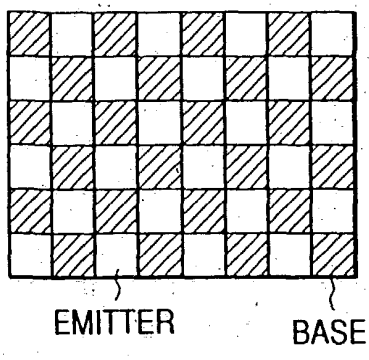


FIG. 20B

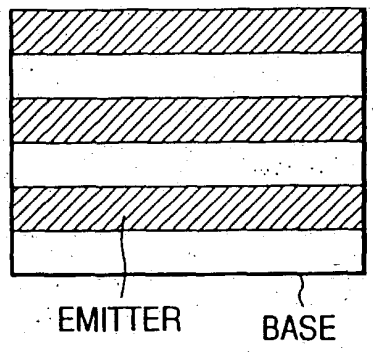


FIG. 21

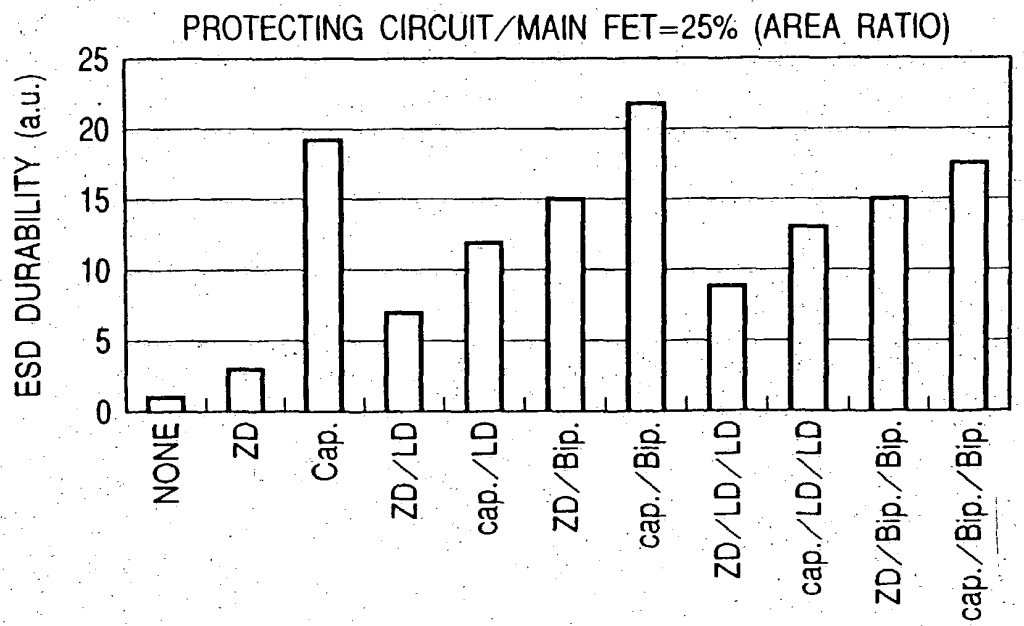


FIG. 22 PRIOR ART

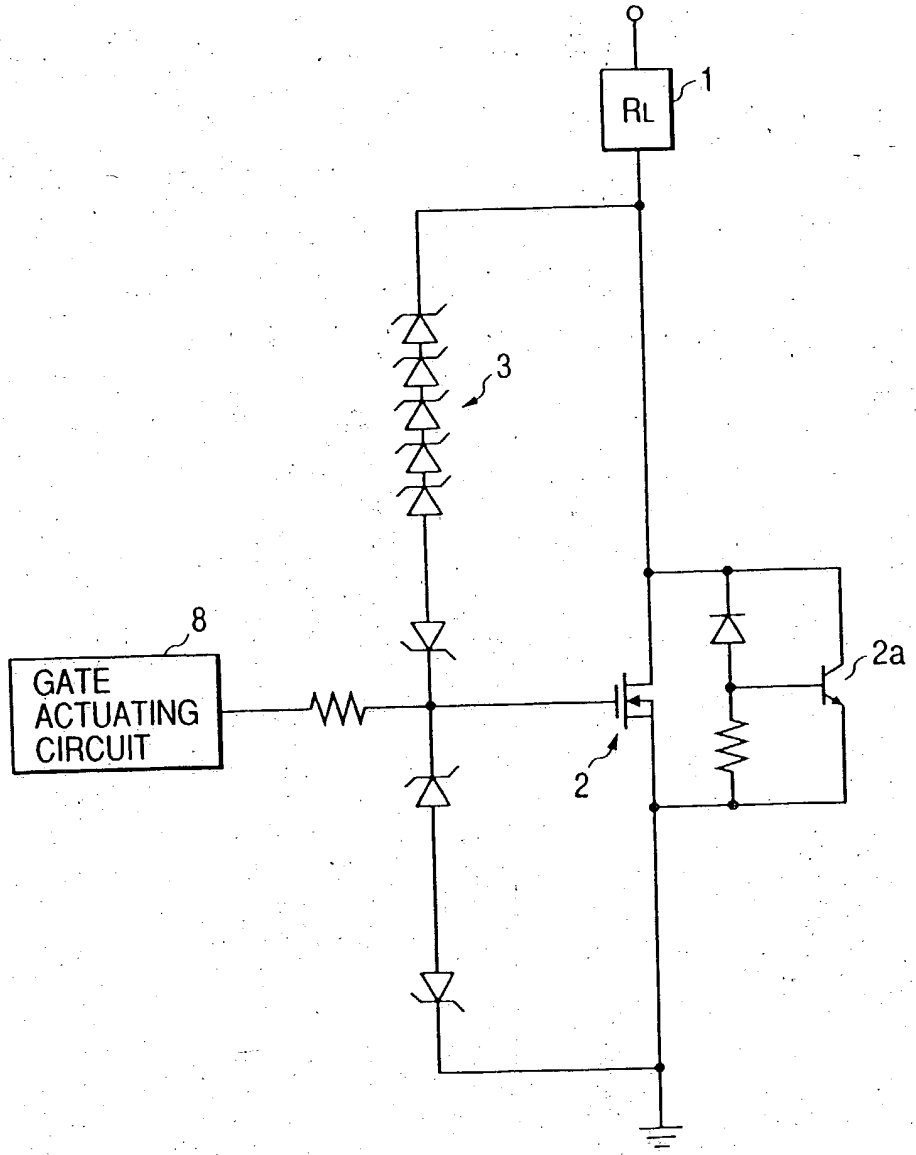


FIG. 23 PRIOR ART

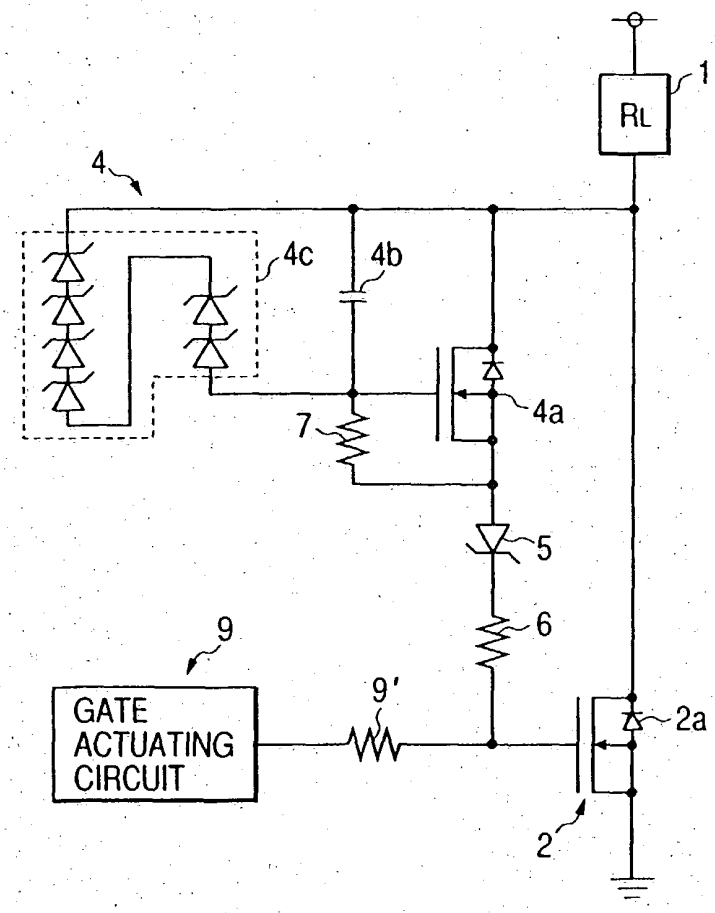


FIG. 24

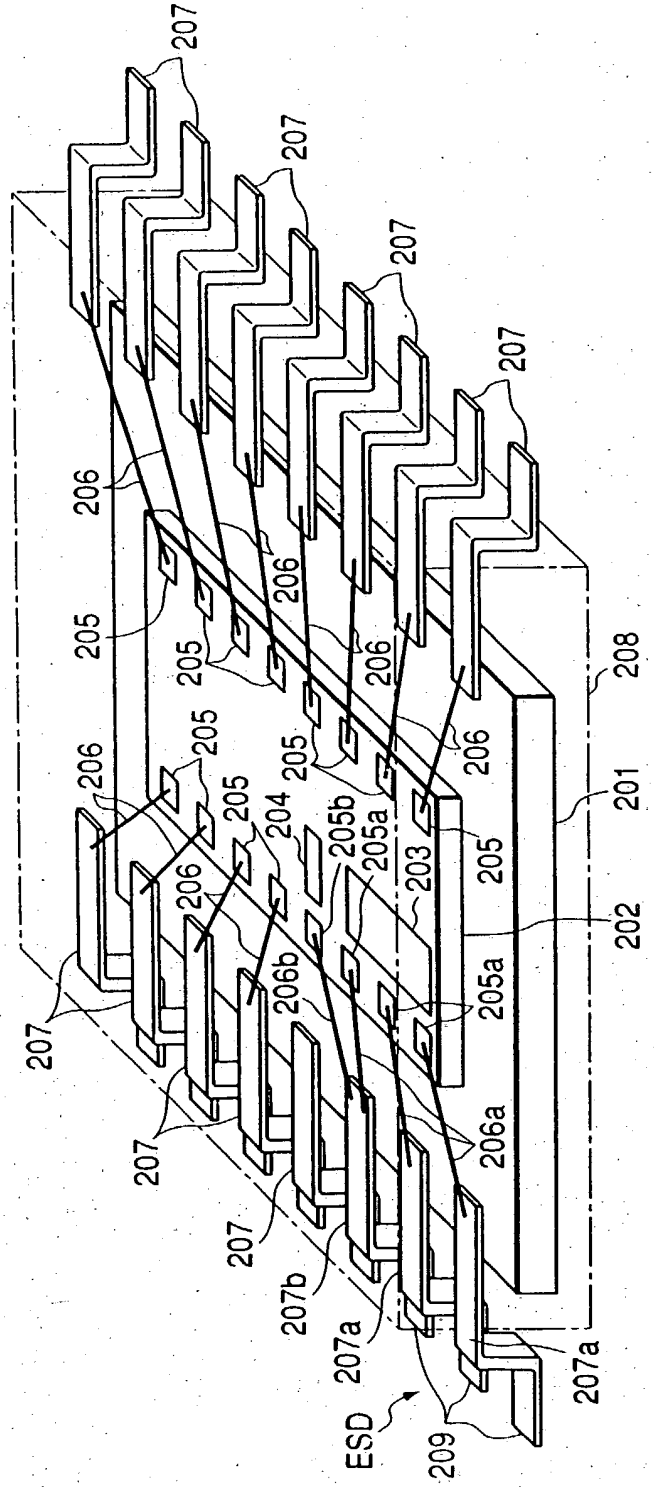

207
207
207
207
206
206
205
205
205
206
206
205
205
206
205
205b
205a
204
206
205
203
206b
205a
205
208
201
202
207
207
207
207b
207a
ESD
209
206a
207a

FIG. 25

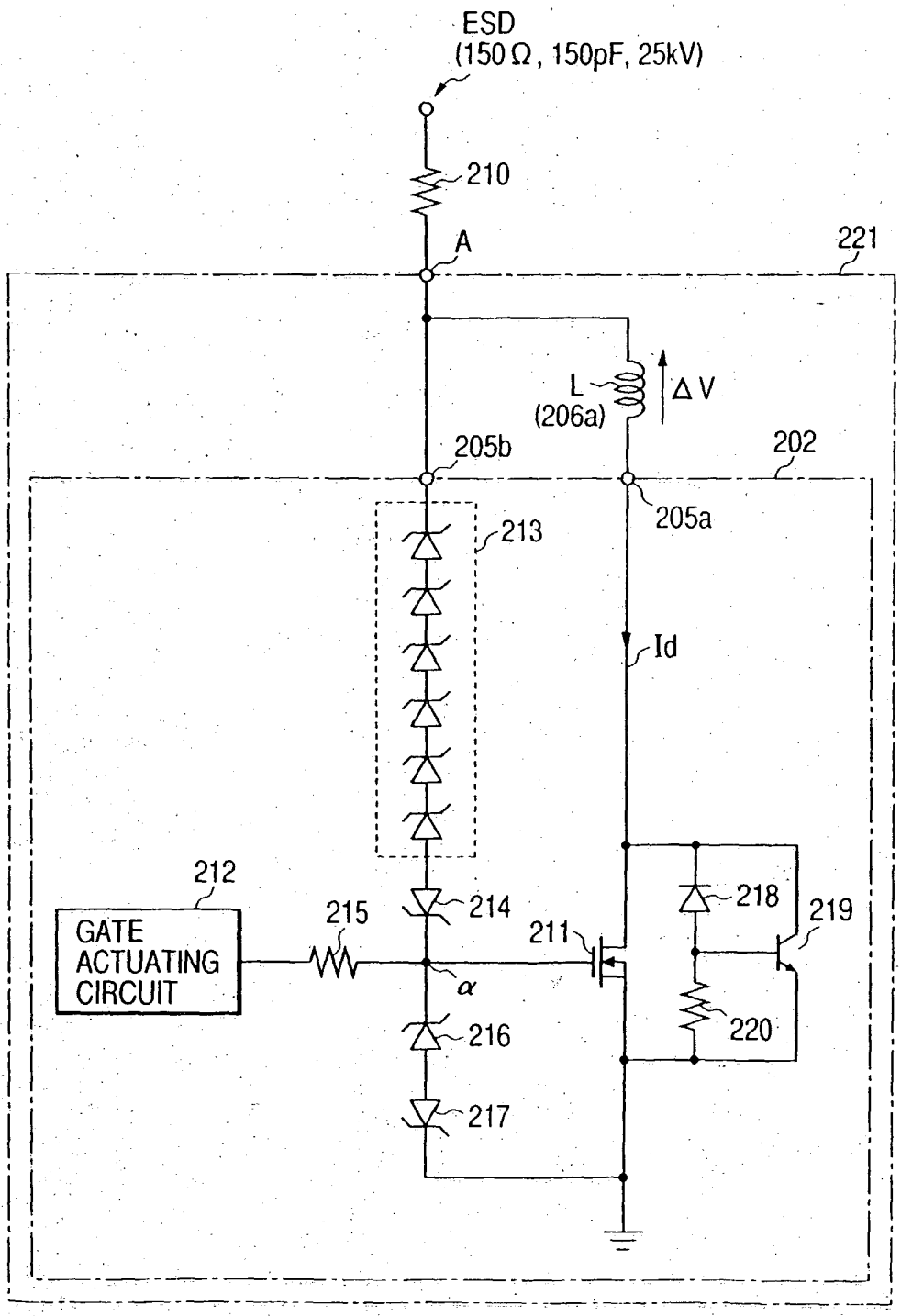

ESD
(150 Ω, 150pF, 25kV)
210
A
221
L
(206a)
ΔV
205b
202
205a
213
Id
212
GATE
ACTUATING
CIRCUIT
215
214
211
218
219
α
220
216
217

FIG. 26

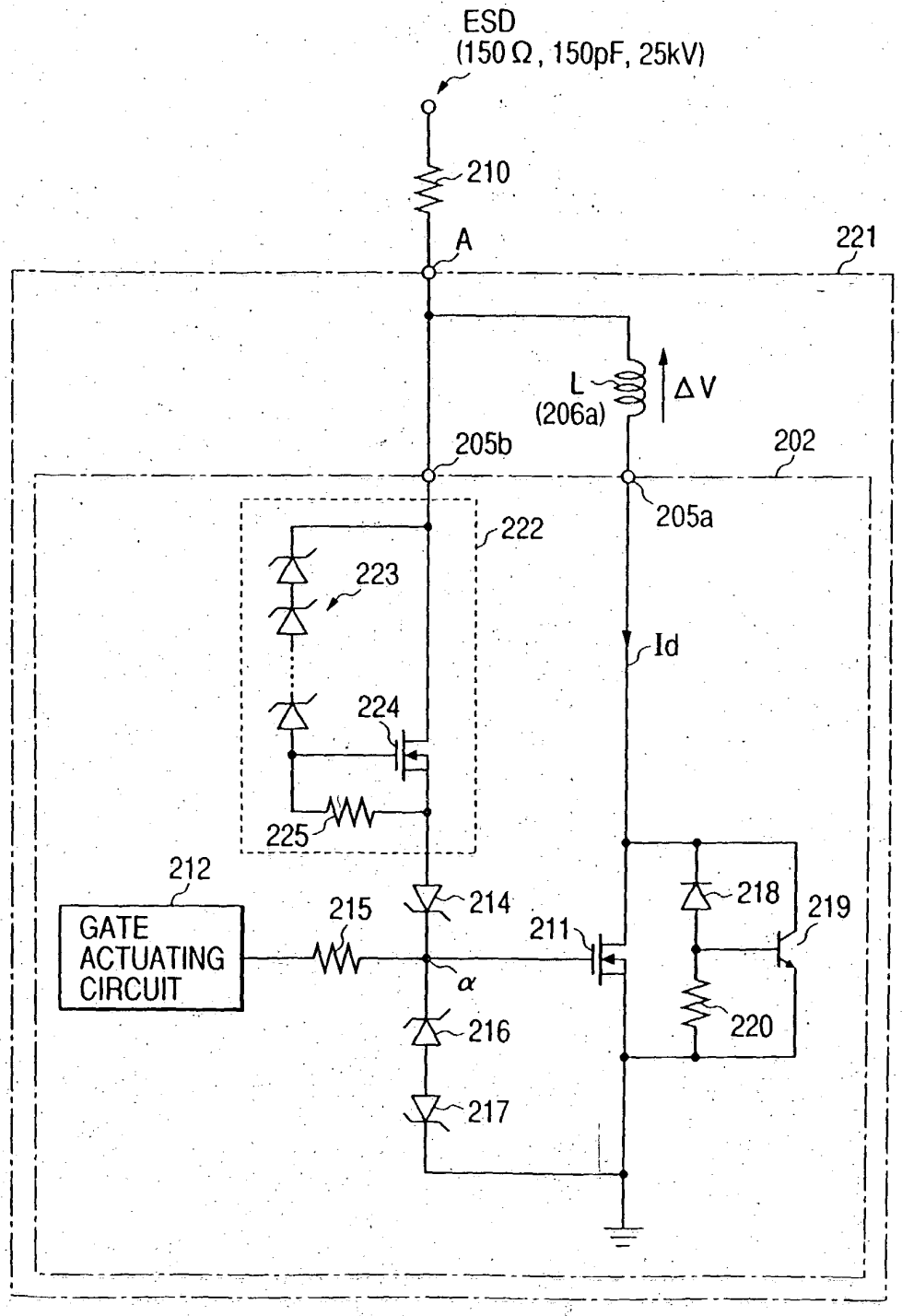

ESD
(150 Ω, 150pF, 25kV)
210
A
221
L
(206a)
ΔV
205b
202
205a
222
223
Id
224
225
212
GATE
ACTUATING
CIRCUIT
215
214
211
218
219
α
220
216
217

FIG. 27

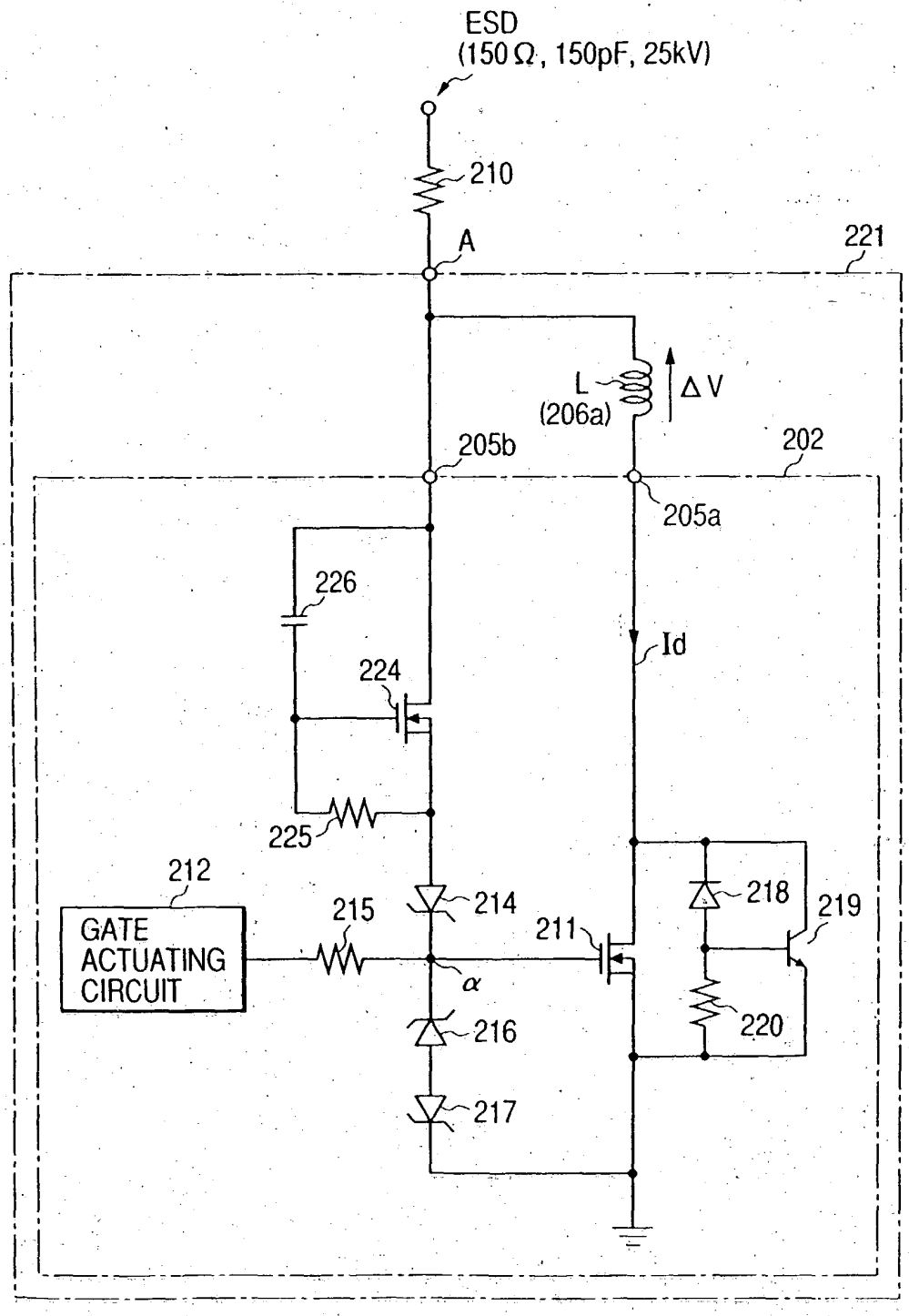

ESD
(150 Ω, 150pF, 25kV)
210
A
221
L
(206a)
ΔV
205b
202
205a
226
Id
224
225
212
GATE
ACTUATING
CIRCUIT
215
214
211
218
219
α
220
216
217

FIG. 28

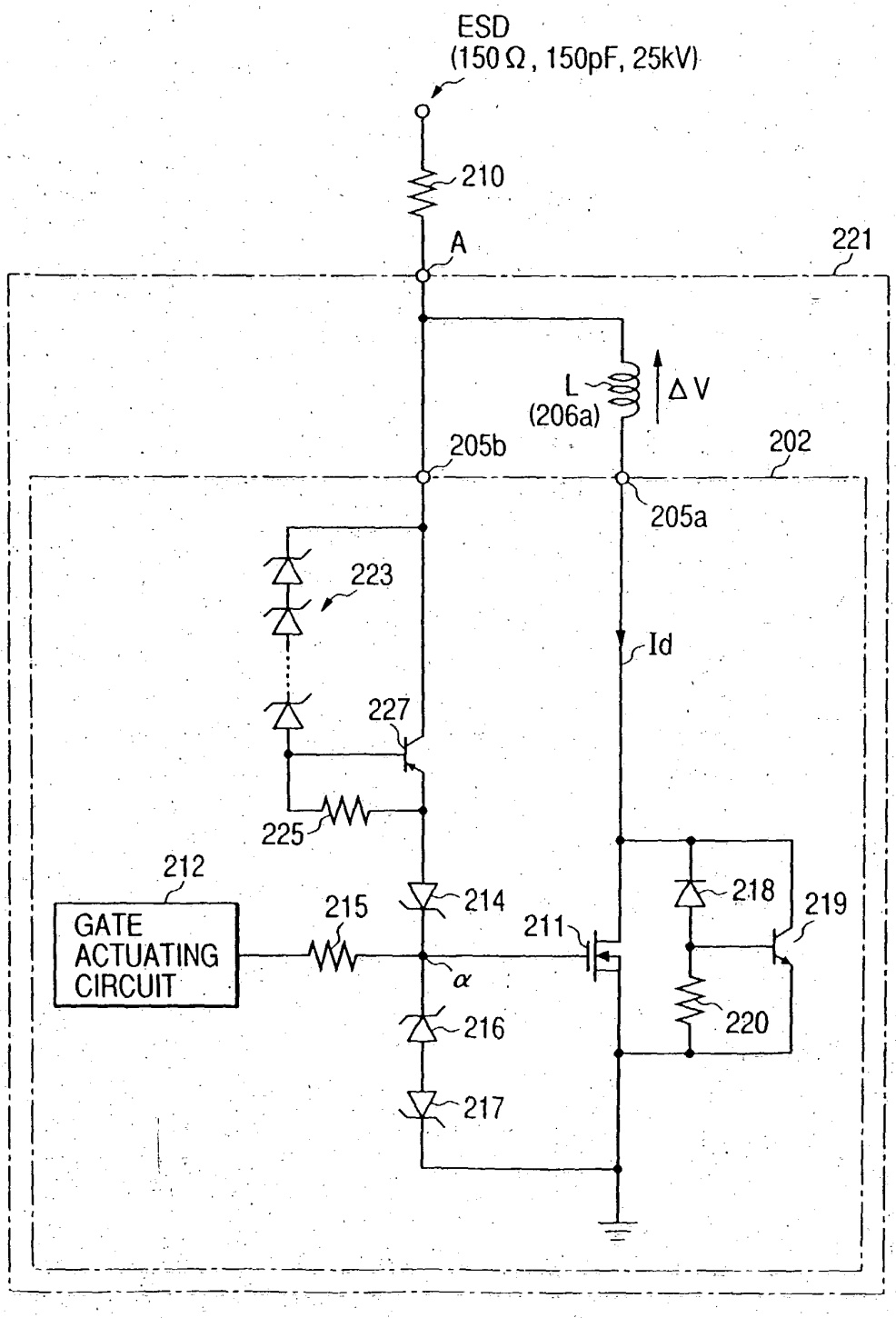

ESD
(150Ω, 150pF, 25kV)
210
A
221
L
(206a)
ΔV
205b
202
205a
223
Id
227
225
212
GATE
ACTUATING
CIRCUIT
215
214
211
218
219
α
220
216
217

FIG. 29

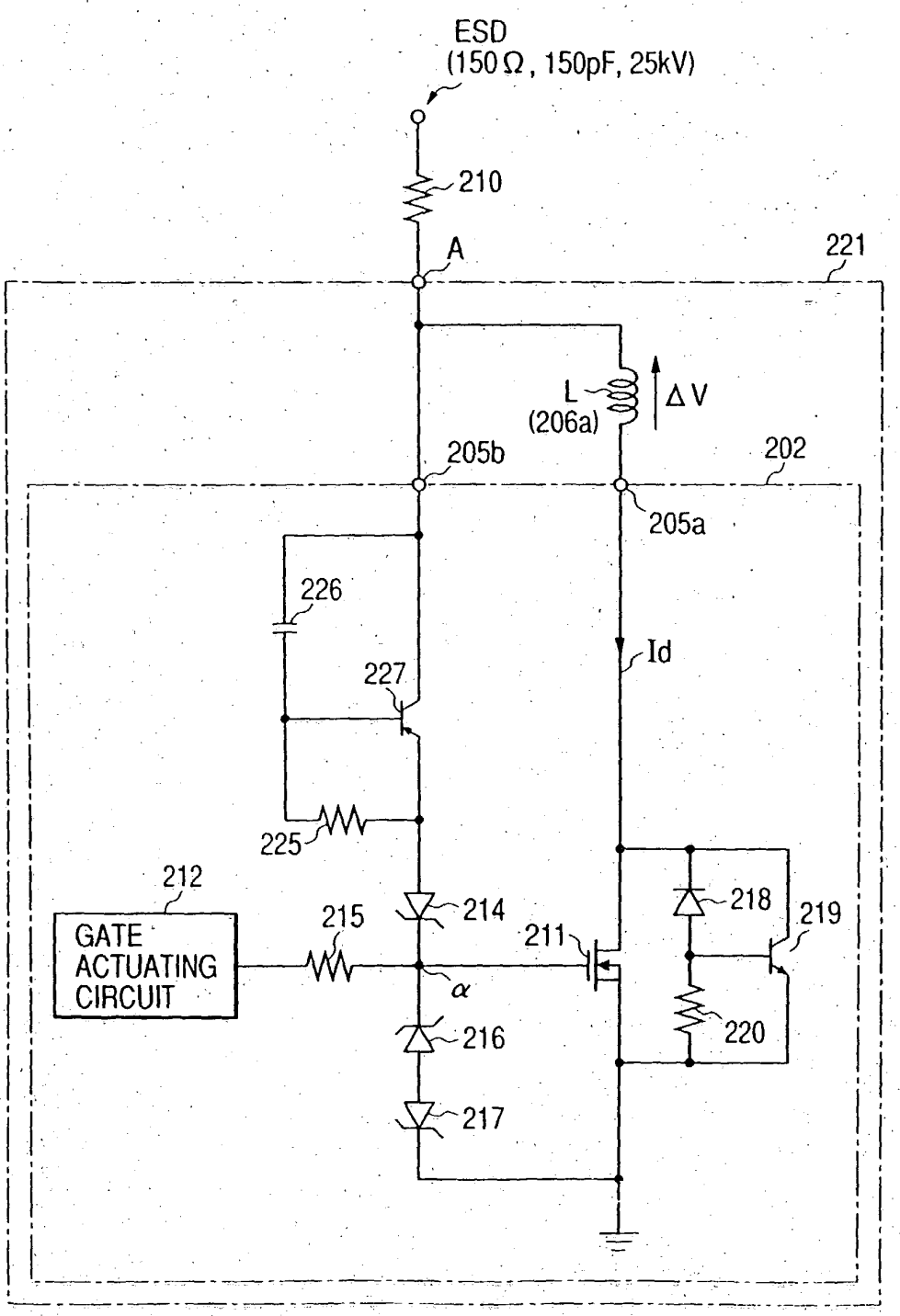

ESD
(150Ω, 150pF, 25kV)
210
A
221
L
(206a)
ΔV
205b
202
205a
226
227
Id
225
212
GATE
ACTUATING
CIRCUIT
215
214
211
218
219
α
220
216
217

FIG. 30

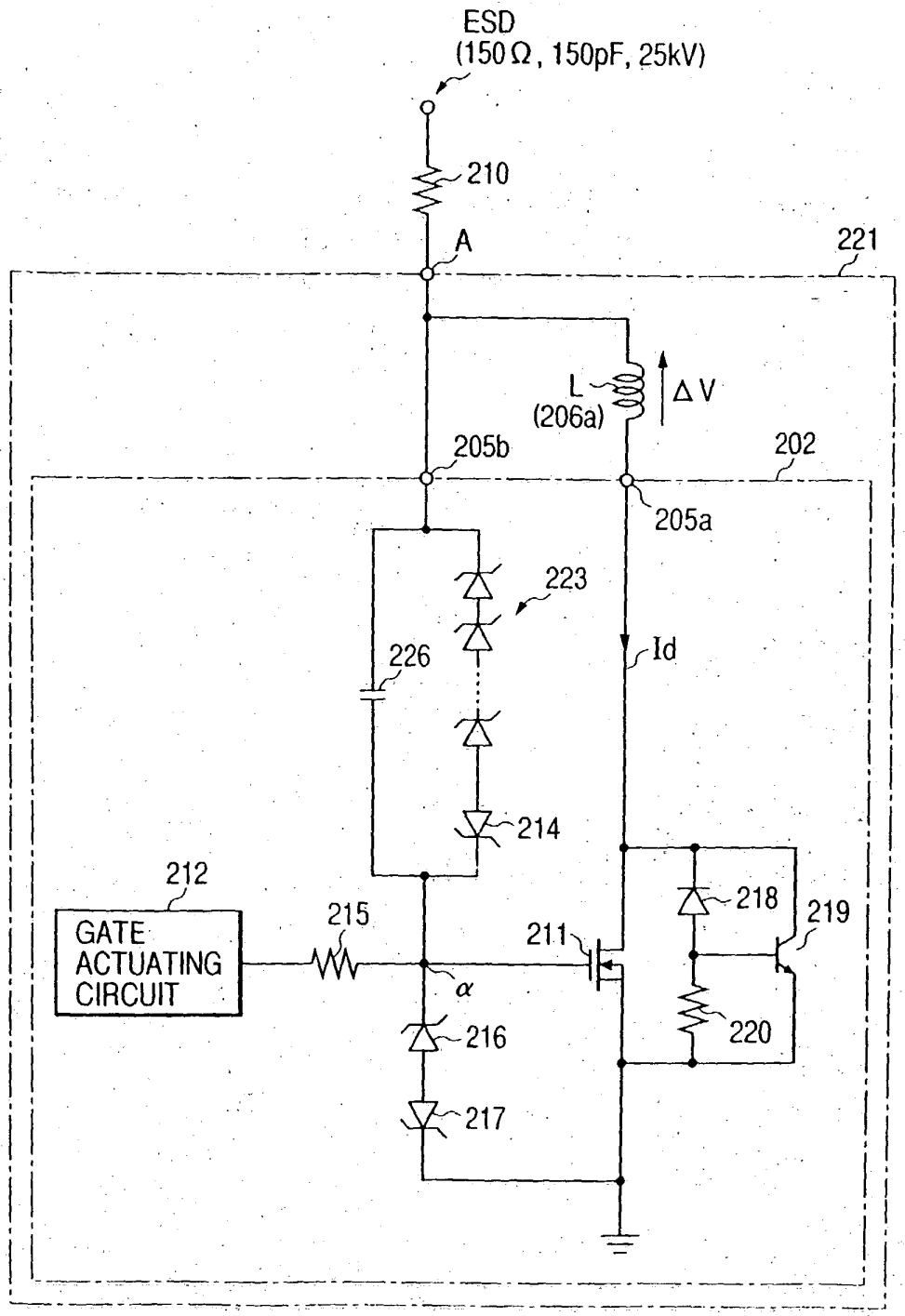
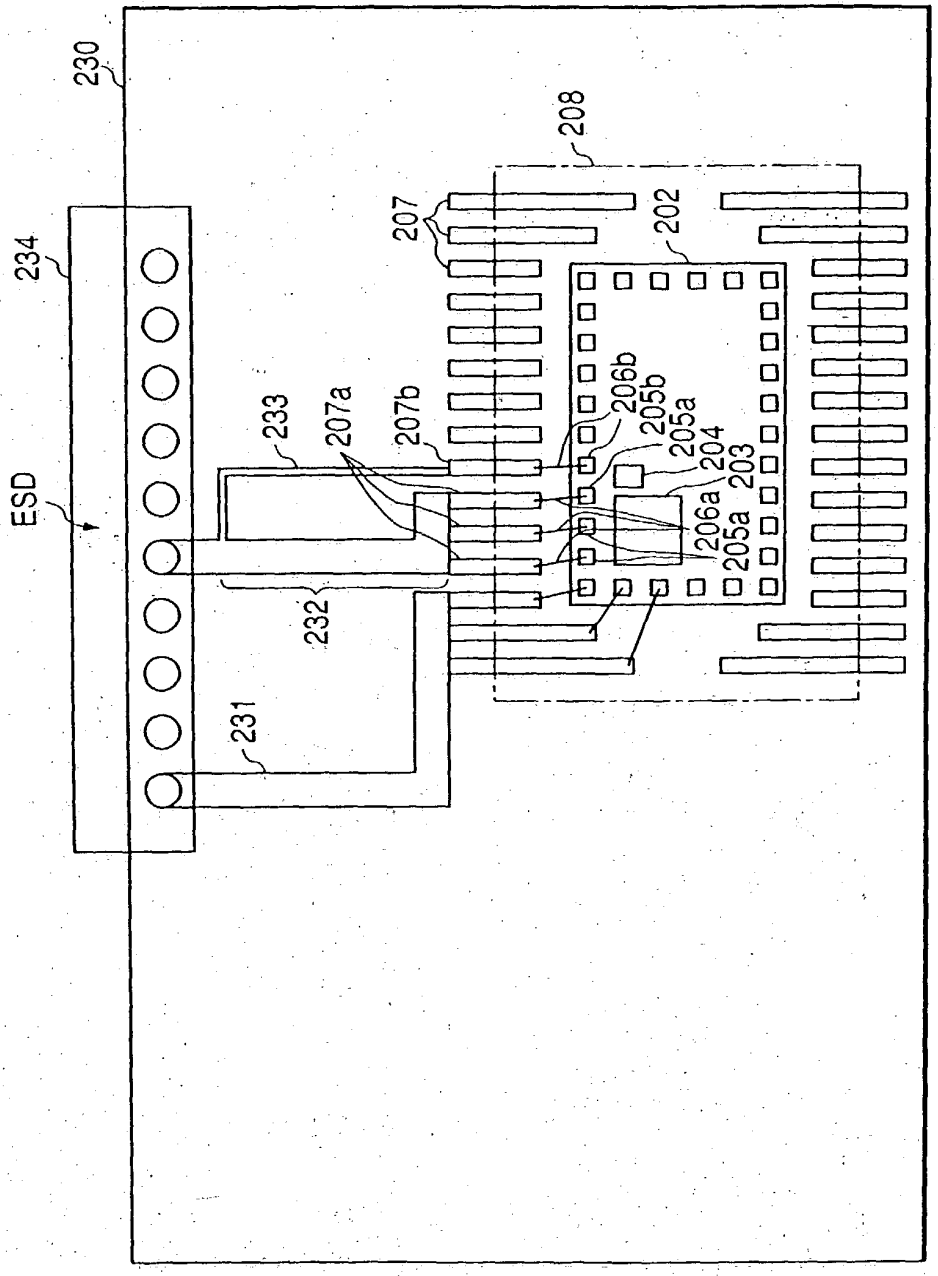

ESD
(150Ω, 150pF, 25kV)
210
A
221
L
(206a)
ΔV
205b
202
205a
223
226
Id
214
212
GATE
ACTUATING
CIRCUIT
215
211
218
219
α
220
216
217

FIG. 31


230
208
207
202
234
206b
205b
205a
204
203
233
207a
207b
ESD
206a
205a
232
231

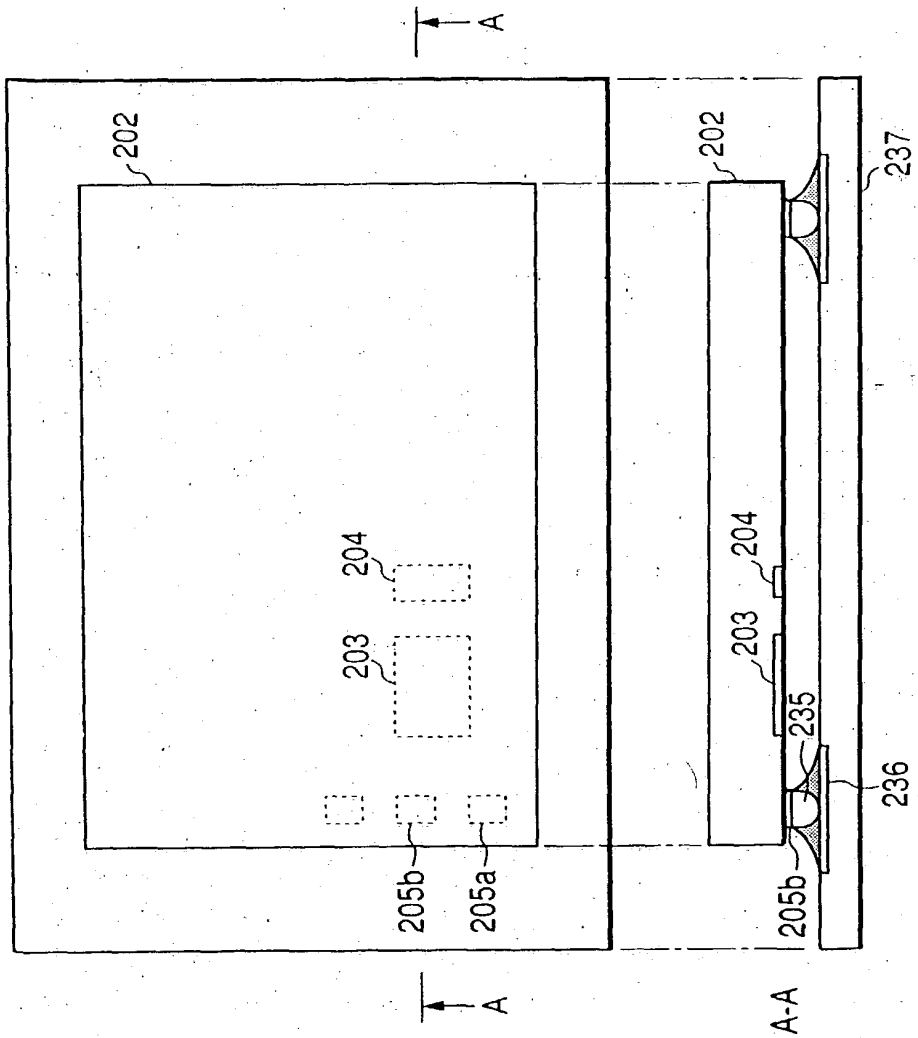


FIG. 32A

FIG. 32B

FIG. 33

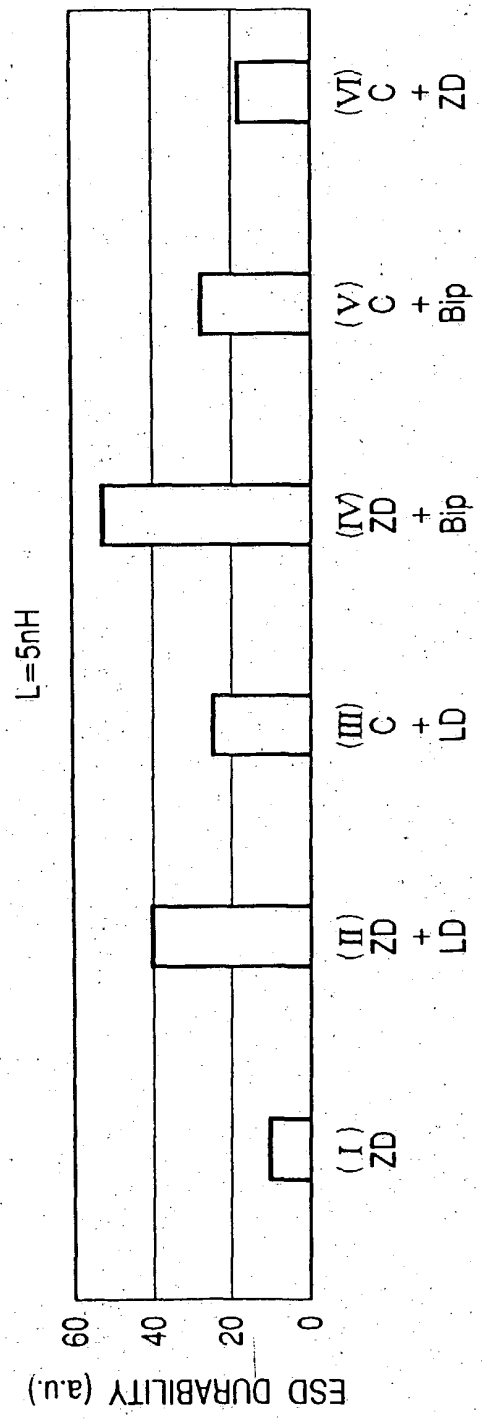

ESD DURABILITY (a.u.)
60
40
20
0
L=5nH
(I) ZD
(II) ZD + LD
(III) C + LD
(IV) ZD + Bip
(V) C + Bip
(VI) C + ZD

FIG. 34

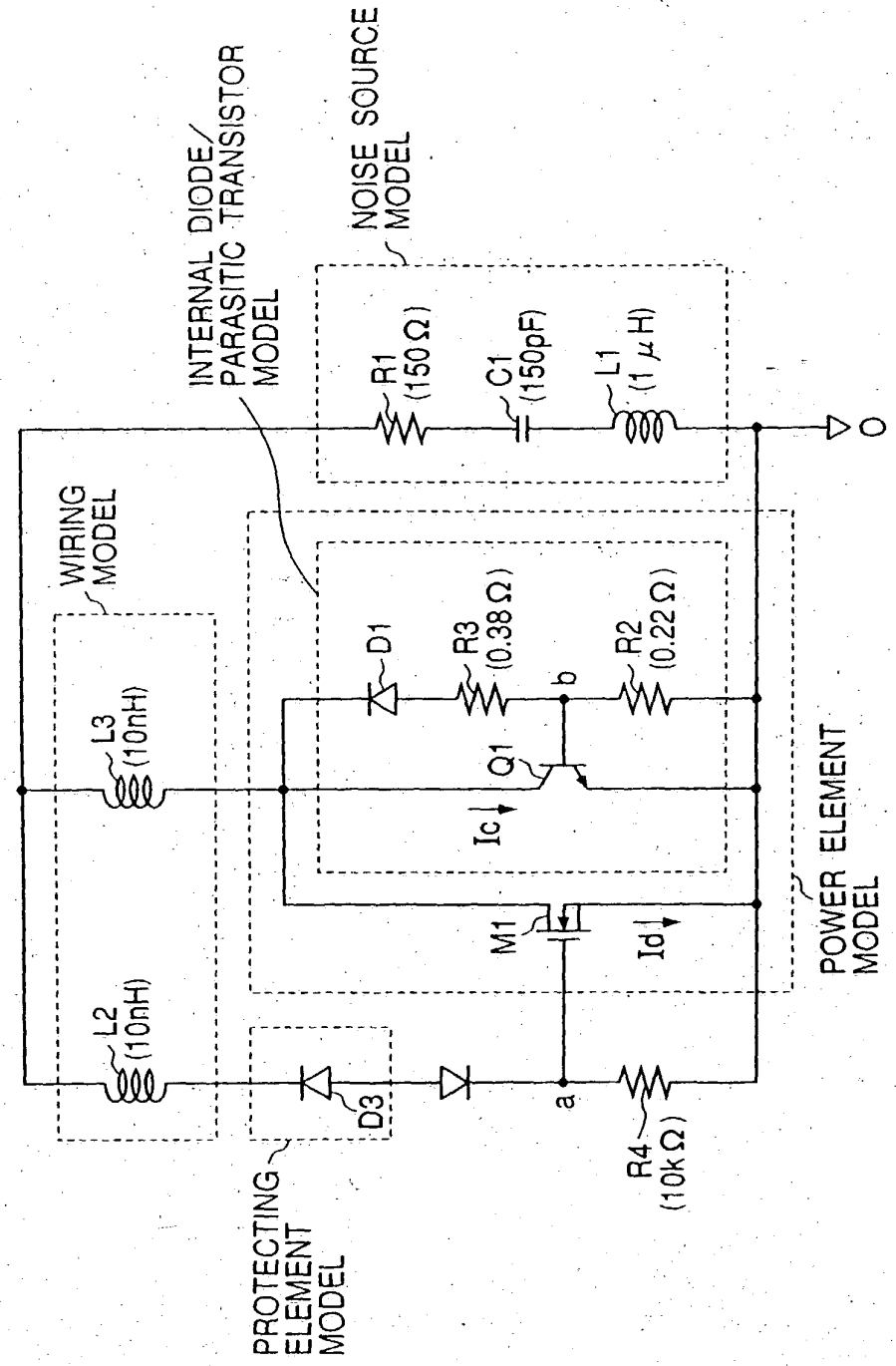

NOISE SOURCE MODEL
INTERNAL DIODE/ PARASITIC TRANSISTOR MODEL
WIRING MODEL
R1 (150Ω)
C1 (150pF)
L1 (1μH)
O
D1
R3 (0.38Ω)
R2 (0.22Ω)
b
L3 (10nH)
Q1
Ic
M1
Id
POWER ELEMENT MODEL
L2 (10nH)
D3
a
R4 (10kΩ)
PROTECTING ELEMENT MODEL

FIG. 35

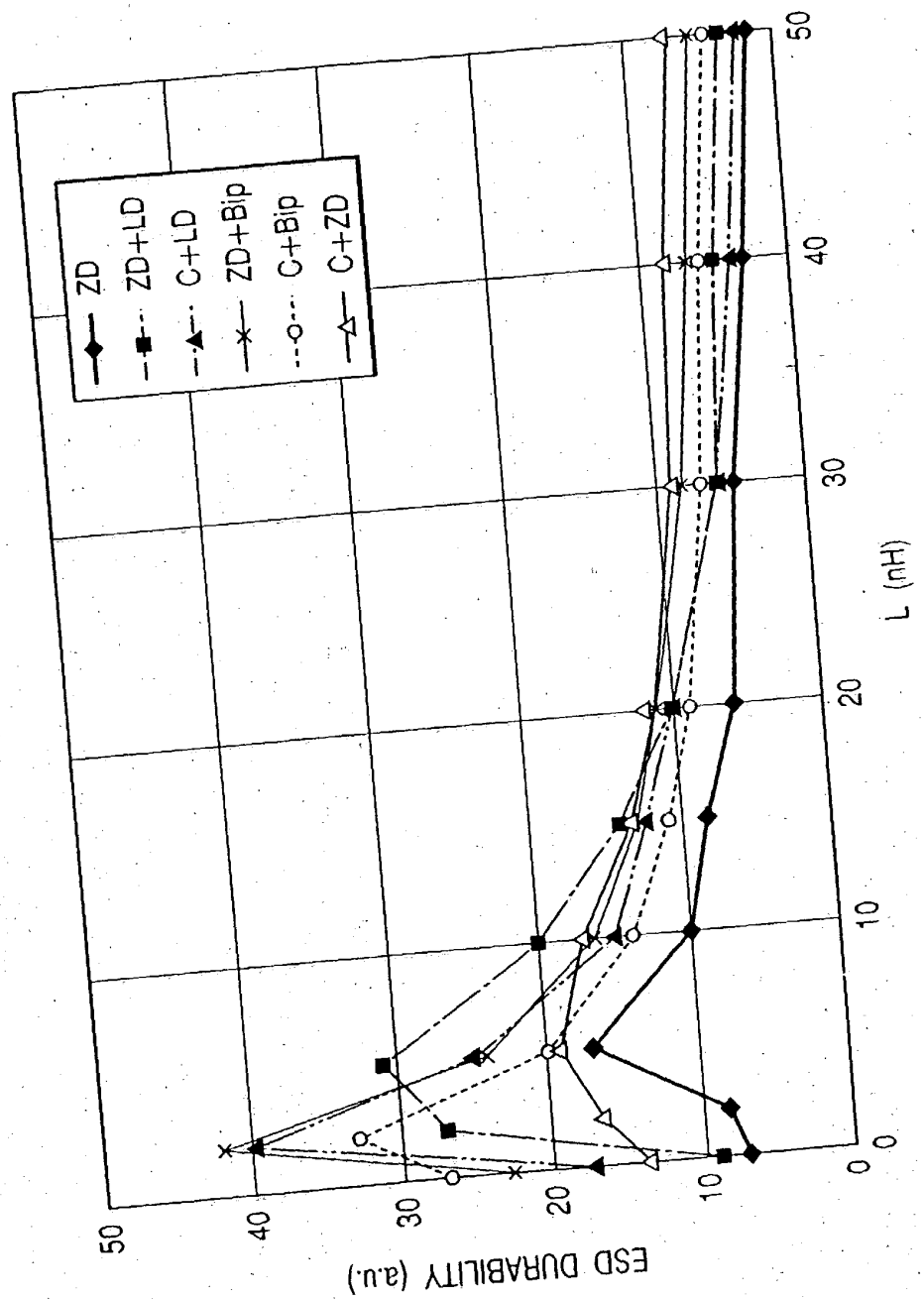

ZD
ZD+LD
C+LD
ZD+Bip
C+Bip
C+ZD
ESD DURABILITY (a.u.)
L (nH)
0
10
20
30
40
50

FIG. 36A

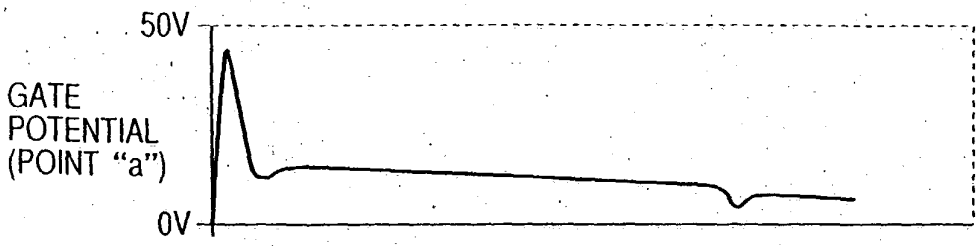


FIG. 36B

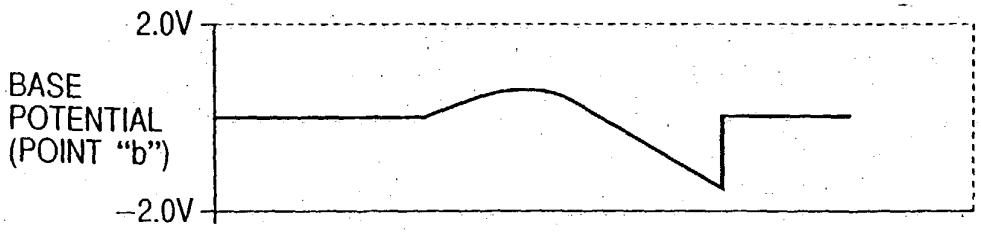


FIG. 36C

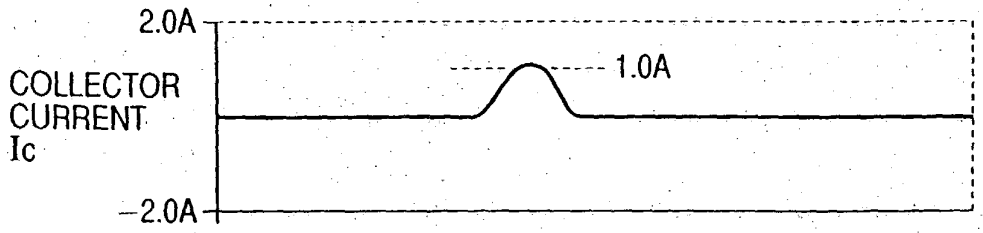


FIG. 36D